Probing the Inner Accretion Disk of AGNs via Kepler Power Spectra

Robert Wagoner
Stanford University

We propose to observe AGNs in Kepler K2 Campaign 6, since this field is ideal for extragalactic observations. Targets will be selected to maximize the fraction of photons in the Kepler band that were emitted from the inner accretion disk. Our major motivation is to search in the power spectra for the analogs of the stable high-frequency quasi-periodic oscillations (HFQPOs) seen in ~8 stellar mass black hole X-ray binaries and one superluminous (~400 solar mass black hole?) X-ray source. The origin of these QPOs is still a mystery, as is the claim that the two highest frequencies are usually in a ratio of 3/2. However, they have the potential of providing a clock very close to the horizon (especially for the many black holes with close to maximum angular momentum). Only one (low-frequency) QPO has been seen (in X-rays) in an AGN. However, the continuum power spectra can also provide valuable information about conditions there, as has been demonstrated by the Kepler observations of Mushotzky et al. (2011), Edelson et al. (2014), and Revalski et al. (2014).

Using realistic models of accretion disks and photon orbits in the Kerr metric, undergraduate Adam Levine (as part of his senior thesis) and the PI (Robert Wagoner) have calculated this photon fraction from a region where the most robust normal mode could exist, as a function of red shift, black hole mass, spin, and disk inclination. These calculations will be a major input to our target selection. As an example, the period of this (g-)mode, which is gravitationally trapped near the temperature maximum of the disk, is (11 □ 40) (M/10^8 solar masses) (1+Z) hours (for maximum □ zero spin). The observed periods of those HFQPOs in binary sources with well-determined black hole masses (and in some cases spin) also obey this relation with a similar coefficient. Large redshifts (Z) are preferred, since the maximum temperature of the disk is ~ 10^5 K for 10^8 solar masses.

We will consider those AGNs that have luminosities that could imply HFQPO periods well within the K2 range of O.5 hours to 80 days. (We will be employing the 30-minute cadence of Kepler.) Various approaches will be employed to maximize the information obtained from the conversion of light curves to power spectra or equivalent. The Collaborator Jeff Scargle will play a leading role in this analysis. This will be a Small Investigation, with < 40 targets.

We have and will continue to involve high school students taught by the Co-I Caroline Odden in this research. We believe this project will serve as a highly engaging STEM activity for these students. Odden teaches an astronomy research course at Phillips Academy, in Andover, Massachusetts.